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## BIOLOGICAL AND CHEMICAL CONTROL OF DWARF MISTLETOE<sup>1/</sup>

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Abstract: Biological and chemical control agents for control of dwarf mistletoe could likely be developed if we elected to develop them. Current attitudes, however, marshal against adequate study of such widespread and virulent fungal parasites as *Cylindrocarpon gillii* and *Colletotrichum gloeosporioides*.

Key words: *Wallrothiella arceuthobii*, *Colletotrichum gloeosporioides*, *Cylindrocarpon gillii*, dwarf mistletoe, biological control, chemical control.

### INTRODUCTION

Forest managers and forest pathologists have long discussed the idea of controlling the dwarf mistletoes with living organisms and with chemicals that can be applied to infected trees and which selectively kill the dwarf mistletoe. After many years, however, we do not have effective chemical poisons nor have we harnessed natural enemies--such as fungi or insects--to use in those situations when silvicultural control isn't effective or appropriate. Why is this so? Is it because dwarf mistletoe has no natural enemies? Is it because these organisms can't be manipulated to our advantage? Is it because the vast North American chemical industry can't develop a selective mistletoe poison?

I would now like to examine biological and chemical control of dwarf mistletoe in more detail. I hope to convince you that the current absence of chemical and biological control agents is more the result of our attitudes than the lack of appropriate organisms or chemicals.

The basic attitude has been that forests are low-value crops and that we cannot afford special treatments, such as flying over an area and spraying spores. Since we can't afford to use them, why bother developing

them? We are better off using our talents to refine normal management practices such as harvesting and thinning as a means of disease reduction. This attitude still prevails, effectively preventing the development of alternative control systems. And, since we have no alternative control schemes, of course there is no way to reduce the cost of these systems. Thus they can never be economically feasible. Neither are they available in situations where cost is not a primary consideration (parks, campgrounds). Another basic attitude on biological control is that if it really worked, dwarf mistletoe wouldn't be a problem, although many report that insects and fungal parasites of mistletoe can be locally damaging. These are the basic attitudes that keep impractical ideas from becoming practical ones.

### BIOLOGICAL CONTROL

Let's talk about biological control first. Like other indigenous plants, the dwarf mistletoes have a number of organisms that do them damage--most are fungi and insects. Some are casual parasites, but many appear to have no other host.

It is probably safe to say that more than half of them are yet to be described. Someday, perhaps we will be able to knowledgeably discuss virus and mycoplasma parasites of the dwarf mistletoes.

The first dwarf mistletoe parasite was reported from New York State (Peck 1875). This was a fungus, *Wallrothiella arceuthobii* (Peck) Sacc. This ascomycete has since been reported throughout much of Canada, the Western United States and Northern Mexico.

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It parasitizes female fruits of the spring flowering dwarf mistletoes--those on Douglas-fir and lodgepole pine in the West and jack pine and black spruce in the East.

Early forest pathologists were basically mycologists with a strong conviction that we cannot manipulate plant systems unless we understand them well. Thus they concentrated their efforts on the biology and classification of organisms. They were, however, very aware of the potential value of manipulating these organisms for human benefits.

In 1915, when speaking of *Wallothiella* in the Idaho-Montana forest region, James Weir said, "It is found to be so abundant as to have some economic significance." Eleanor Dowding said much the same about this fungus on lodgepole pine mistletoe in Alberta in 1929; "...Its presence is probably of considerable importance in limiting the spread of *Arceuthobium*."

They went on to do some very good work on the biology and epidemiology of this fungus, but no attempts were made to use the fungus for biological control.

Lake Gill, another leader in the field of forest pathology, discovered (in 1932) a white fungus attacking dwarf mistletoe aerial shoots. In his 1935 publication he said it was "apparently responsible for the premature death of large numbers of [mistletoe] shoots in that area."

This fungus, now called *Cylindrocarpon gillii* (Ellis) J. A. Muir, was found by Gill on the dwarf mistletoes of western hemlock, true fir, western spruce and Mexican white pine, *Pinus strobiformis* (Gill 1935). The list of dwarf mistletoes parasitized by this fungus was expanded by Ellis (1939, 1946) to include those of Douglas-fir, piñon pine, ponderosa pine, sugar pine, limber pine and Digger pine. Later Gill (1952) reported this fungus on lodgepole pine dwarf mistletoe from Montana where the dwarf mistletoe "suffered heavy mortality." Wicker and Shaw (1968) added western larch dwarf mistletoe to the list.

The fungus has been reported from the States of Arizona, California, Montana, New Mexico, Oregon, Utah, Washington, Wyoming, and from the provinces of British Columbia, Alberta, and Saskatchewan (Kuijt 1960-61). A recent paper details the distribution of *Wallothiella* along with *Cylindrocarpon* and *Colletotrichum*, the three major fungal parasites of the dwarf mistletoes (Hawksworth et al. 1977).

Certainly a fungus attacking so many dwarf mistletoes, often severely, over such a vast region deserves our professional attention. So let's focus on this fungus as our object-organism, follow it through the years since it was described, and see why it's still in the scientific journals instead of in the land manager's tool kit.

After noting the severity of the fungus and after sketching in the general geographic range, Ellis took the correct next step: he did a comprehensive study of the biology of this fungus (Ellis 1946), making the following main points:

1. It is found on dwarf mistletoe on 29 tree species.
2. Female plants are more frequently infected than are male plants.
3. Both immature and mature dwarf mistletoe plants are attacked.
4. It is a cool weather disease, growing slowly at 5°C, best at 17°C, and not at all at 22°C.
5. Of some 1,100 inoculated dwarf mistletoe shoots, 27 percent (range 0-90 percent) became infected. Most tests were on Douglas-fir dwarf mistletoe, but he also inoculated dwarf mistletoes on several pines in the Southwest.

He concluded by saying, "It is quite evident that *Septogloeum gillii* (now *Cylindrocarpon*) is responsible for considerable control of dwarf mistletoe under natural conditions, but further studies will be necessary to determine whether or not its introduction into new areas for purposes of biological control would be practical."

Thirteen years elapsed until Mielke (1959) published results of a study he did on establishing *Cylindrocarpon* in new areas. It didn't work well, but for understandable reasons.

Mielke collected spores on the Kaibab plateau in July from infected piñon pine and did his experiments 2 weeks later on the Cache National Forest in northern Utah and the Targhee National Forest in eastern Idaho, inoculating infected lodgepole pine. He did establish the fungus in 42 of 50 inoculated trees. It maintained its presence for 3 years and then died out. We have learned that moving plants too far from their place of origin often yields questionable and erratic results. Also, using spores from piñon pine mistletoe and

inoculating lodgepole pine dwarf mistletoe is somewhat chancey. In culture dishes, *Cylindrocarpon*'s growth is distinct enough so that we can tell the dwarf mistletoe host by the characteristics of the fungus colony. I would expect some host specificity in the forest also. In any case, it is exactly at this point in the drama that pathologists should become interested in asking--and answering--some sound pathology questions.

- What is the host specificity and pathogenicity of these isolates?
- Are spores not being produced?
- Are the spores not germinating?
- Is the dew-period too short, or temperatures too cold for the germ tube to grow and penetrate?

These, and other questions, would help establish the factors limiting the success of the organisms. Conversely, what characterized areas where this fungus is causing severe infection?

Both Gill (1952) and Mielke (1959) suggest that wet weather promotes growth and spread of *Cylindrocarpon*; however, the optimum dew-period, moisture drop size, etc. have not been established. Wet weather alone is not sufficient to cause epidemic levels of *Cylindrocarpon*. Marys Peak in the Oregon Coast forest is very wet for a large portion of the year, yet *Cylindrocarpon* is not found on every hemlock dwarf mistletoe plant. It is possible that insufficient moisture occurs at the time the temperature is warm enough for maximum spore production. Again, this is easy to determine. The Marys Peak hemlock dwarf mistletoe infestation is not a vigorous epidemic. *Cylindrocarpon* and a resin disease are both contributing to the debilitation of the mistletoe. There are probably other undiscovered influences.

A third very important fungal parasite of the dwarf mistletoes is *Colletotrichum gloeosporioides* Penz. This was first reported by Parmeter et al. (1959) from California. Current known range includes all Western States except Nevada and Wyoming (Hawksworth et al. 1977). It has been studied in the lab and in the forest and possesses characteristics that make it a promising biological control agent. Spores are easily produced, and these germinate over a wide range of temperatures. Disease development is rapid (2-3 weeks) and the damage severe (Parmeter et al. 1959).

These three fungi are well respected, but currently unemployed. I hope current interest in biological control (Baker and Cook 1974) coupled with the development of techniques for determining how safe these organisms are (Wapshere 1974) will help make biological control more attractive in forest management.

#### CHEMICAL CONTROL

Of 95 references in the mistletoe FAMULUS<sup>3/</sup> reference file on chemical control, 28 mention dwarf mistletoe. Of these 28, 14 are anonymous references to interim reports, annual summaries of activities, and other non-technical outlets. There has been a strong interest in chemicals by persons concerned with the dwarf mistletoe problem who felt the need for alternatives to silvicultural control. This interest and concern began to surface in the reports of spraying results that first appeared in the early 1950's and continued at the rate of about one report per year for a decade. Most compounds tested were commercially available herbicides.

Results were largely negative and persistently erratic, prompting Harold Offord (1960) to state, "Of the many compounds and formulations so far tested on dwarf mistletoes, none has looked very exciting." The following year Shea (1961) said, "We urgently need development of promising chemicals that will permit selective absorption and translocation in the parasite and host plant."

Clarence Quick (1964) published a summary of 246 tests on 2,516 trees of Jeffrey, ponderosa and sugar pine in California. He optimistically concluded his report saying, "When all established tests have matured, it is believed that a safe, reasonably effective direct chemical control of dwarf mistletoe on pines can be defined." It has been 14 years since Quick's report; and many attempts later, we must conclude that the development of an effective, selective chemical poison for dwarf mistletoe is still in the early stages. Like Edison and his light bulb, we know a lot of things that don't work! And there are some slim leads. Greenham and Leonard (1965) discovered an amino acid, hydroxyproline, in true fir dwarf mistletoe, but not in the host tree. They propose that analogs of this amino acid might be used for mistletoe control: "How toxic analogs would be to plants containing free hydroxyproline is not known at present."

<sup>3/</sup> On file at Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

So many factors are involved in selective toxicity that the effectiveness of a potential selective herbicide can be gauged only by direct experimentation. The above investigation has given leads worthy of further attention." These leads have not been followed up.

Leonard and Hull have also published several comprehensive papers on translocation, nutrition, and photosynthesis of dwarf mistletoes (Leonard and Hull 1965; Hull and Leonard 1964). Among other important papers, one is on translocation (Rediske and Shea 1961) and two on water relations of dwarf mistletoe (Mark and Reid 1971; Fisher 1975). Work at Portland State University, Oregon, on dwarf mistletoe photosynthesis and respiration (Miller and Tocher 1975; Gustafson and Tocher, personal communication), dwarf mistletoe hormones (Paquet and Tinnin, personal communication), and aspects of dwarf mistletoe stomates and phloem tissue (Calvin, personal communication) is helping to provide ground work for understanding some of the main aspects of the problem of chemical control of dwarf mistletoe, namely:

1. Moving the poison throughout the tree.
2. Moving the poison to the infections.
3. Moving a poison from the tree tissue into the mistletoe tissue.

Of these, number 3 is the most important. If efforts here are successful, aspects 1 and 2 will be relatively easy.

In summary, biological and chemical control agents are not now operational options available to managers. Nor will they be in the future unless we convince ourselves that we truly need control methods other than the chain saw.

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